CLAIMS

What is claimed is:

1. A method for forming a plurality of permanent magnets with two different north-south magnetic pole alignments, comprising the steps of:
   (a) magnetizing each permanent magnet with the same north-south magnetic pole alignment; and
   (b) switching the north-south magnetic pole alignment of a portion of the permanent magnets by:
      (i) temporarily heating the portion of the permanent magnets to a temperature in the range of 0 - 200 °C below a Curie temperature thereof, thereby reducing a first threshold for switching of the north-south magnetic pole alignment of the portion of the permanent magnets; and
      (ii) exposing the portion of the permanent magnets to a magnetic field which is directed oppositely to the north-south magnetic pole alignment of the permanent magnets, with the oppositely-directed magnetic field having a magnetic field strength which is above the first threshold for switching the alignment of the portion of the permanent magnets, while being below a second threshold for switching of the north-south magnetic pole alignment for a remainder of the permanent magnets.
2. The method of Claim 1 wherein the permanent magnets comprise rare-earth permanent magnets.
3. The method of Claim 1 wherein the portion of the permanent magnets comprise neodymium-iron-boron (NdFeB) permanent magnets.
4. The method of Claim 3 wherein the remainder of the permanent magnets comprise samarium-cobalt (SmCo) permanent magnets.
5. The method of Claim 4 wherein the oppositely-directed magnetic field is produced, at least in part, by the SmCo permanent magnets.
6. The method of Claim 5 further including a step of locating a soft-magnetic plate proximate to at least one pole of the SmCo permanent magnets for enhancing the oppositely-directed magnetic field.

7. The method of Claim 1 wherein the permanent magnets are located on or within a substrate.

8. The method of Claim 7 wherein the permanent magnets are arranged in a side-by-side arrangement, and the portion of the permanent magnets comprises every other permanent magnet in the side-by-side arrangement.

9. The method of Claim 1 wherein the permanent magnets are arranged in a two-dimensional array, and the portion of the permanent magnets comprises every other row of permanent magnets in the two-dimensional array.

10. The method of Claim 1 wherein the step of exposing each permanent magnet in the portion of the permanent magnets to the oppositely-directed magnetic field comprises providing an external magnetic field for generating the oppositely-directed magnetic field.

11. The method of Claim 10 wherein the step of exposing each permanent magnet in the portion of the permanent magnets to the oppositely-directed magnetic field comprises a step of concentrating the external magnetic field at the location of each permanent magnet within the portion of the permanent magnets.

12. The method of Claim 11 wherein the step of concentrating the external magnetic field at the location of each permanent magnet in the portion of the permanent magnets comprises locating a soft-magnetic material proximate to at least one pole of each permanent magnet in the portion of the permanent magnets.

13. The method of Claim 12 wherein the step of locating the soft-magnetic material proximate to at least one pole of each permanent magnet in the portion of the permanent magnets comprises providing the soft-magnetic material on or within a plate formed from a non-magnetic material.

14. The method of Claim 12 wherein the step of locating the soft-magnetic material proximate to at least one pole of each permanent magnet in the portion of the permanent magnets comprises providing the soft-magnetic material in the form of a soft-magnetic plate.

15. The method of Claim 14 wherein the soft-magnetic plate is shaped to provide the oppositely-directed magnetic field to the portion of the permanent magnets, and to further direct the external magnetic field into the remainder of the permanent magnets in a direction substantially equal to the north-south magnetic field alignment thereof.

16. The method of Claim 15 wherein the external magnetic field is generated by an electrical current passing through a meandering electrical conductor disposed within a plurality of elongate slots formed in the soft-magnetic plate.

17. A method for forming a plurality of permanent magnets with two opposite north-south magnetic pole alignments, comprising the steps of:

(a) providing a first set of the permanent magnets having a first Curie temperature;

(b) providing a second set of the permanent magnets having a second Curie temperature lower than the first Curie temperature;

(c) magnetizing the first and second sets of the permanent magnets with the same north-south magnetic pole alignment; and

(d) switching the north-south magnetic pole alignment of the second set of the permanent magnets by temporarily heating each permanent magnet in the second set of the permanent magnets to a temperature in the range of 0 - 200 °C below the second Curie temperature in the presence of a magnetic field which is oppositely directed to the north-south magnetic pole alignment of the first and second sets of the permanent magnets, with the magnetic field being above a first threshold for switching the north-south magnetic pole alignment of the second set of the permanent magnets at the temperature to which the second set of the permanent magnets are temporarily heated and below a second threshold for switching the north-south magnetic pole alignment of the first set of the permanent magnets.

18. The method of Claim 17 wherein the first set of the permanent magnets comprises samarium-cobalt (SmCo) permanent magnets.

19. The method of Claim 18 wherein the second set of the permanent magnets comprises neodymium-iron-boron (NdFeB) permanent magnets.

20. The method of Claim 17 wherein the steps of providing the first and second sets of the permanent magnets comprises providing the first and second sets of the permanent magnets on or within a substrate.
21. The method of Claim 20 wherein the steps of providing the first and second sets of the permanent magnets further comprises providing an alternating arrangement of the permanent magnets from the first and second sets of the permanent magnets.
22. The method of Claim 20 wherein the steps of providing the first and second sets of the permanent magnets further comprises providing an array of the permanent magnets, with a plurality of rows in the array being formed from the second set of the permanent magnets, and with a remainder of the rows in the array being formed from the first set of the permanent magnets.
23. The method of Claim 22 wherein the rows in the array formed from the second set of the permanent magnets are alternated with the rows in the array formed from the first set of the permanent magnets.
24. The method of Claim 17 wherein the oppositely-directed magnetic field is produced, at least in part, by the first set of the permanent magnets.
25. The method of Claim 24 further including a step of locating a soft-magnetic plate proximate to at least one pole of each permanent magnet in the first set of the permanent magnets for enhancing the oppositely-directed magnetic field.
26. The method of Claim 17 wherein the oppositely-directed magnetic field comprises an external magnetic field.
27. The method of Claim 26 further comprising a step of concentrating the external magnetic field at the location of each permanent magnet in the second set of the permanent magnets.
28. The method of Claim 27 wherein the step of concentrating the external magnetic field at the location of each permanent magnet in the second set of the permanent magnets comprises locating a soft-magnetic material proximate to at least one pole of each permanent magnet in the second set of the permanent magnets.

29. The method of Claim 28 wherein the step of locating the soft-magnetic material proximate to at least one pole of each permanent magnet in the second set of the permanent magnets comprises providing the soft-magnetic material on or within a plate formed from a non-magnetic material.
30. The method of Claim 28 wherein the step of locating the soft-magnetic material proximate to at least one pole of each permanent magnet in the second set of the permanent magnets comprises providing the soft-magnetic material as a soft-magnetic plate.
31. The method of Claim 17 wherein the first Curie temperature is in the range of 700 - 800 °C, and the second Curie temperature is in the range of 300 - 400 °C.

32. A method for forming a first set of permanent magnets with a north-south magnetic pole alignment and a second set of permanent magnets with an opposite north-south magnetic pole alignment, comprising steps of:

(a) forming the first set of permanent magnets on or within a substrate in an unmagnetized state, with the first set of permanent magnets having a first Curie temperature;

(b) forming the second set of permanent magnets on or within the substrate in an unmagnetized state, with the second set of permanent magnets having a second Curie temperature lower than the first Curie temperature;

(c) magnetizing the first and second sets of permanent magnets with the same north-south magnetic pole alignment;

(d) switching the north-south magnetic pole alignment of the second set of the permanent magnets by:

(i) heating the first and second sets of permanent magnets to a temperature in a range of 0 - 200 °C below the second Curie temperature;

(ii) exposing the first and second sets of permanent magnets to a magnetic field oppositely directed to the north-south magnetic pole alignment of the first set of permanent magnets, with the magnetic field being above a threshold for switching the north-south magnetic pole alignment of the second set of permanent magnets while being below another threshold for switching the north-south magnetic pole alignment of the first set of permanent magnets; and

(iii) cooling the first and second sets of permanent magnets and thereby locking in an oppositely-directed north-south magnetic pole alignment for the second set of permanent magnets.

33. The method of Claim 32 wherein the first set of permanent magnets comprises samarium-cobalt (SmCo) permanent magnets, and the second set of permanent magnets comprises neodymium-iron-boron (NdFeB) permanent magnets.

34. The method of Claim 32 wherein the cooling step comprises cooling the first and second sets of permanent magnets down to room temperature.

35. A method for forming a plurality of permanent magnets with two different north-south magnetic pole alignments, comprising the steps of:

(a) magnetizing each permanent magnet with the same north-south magnetic pole alignment; and

(b) switching the north-south magnetic pole alignment of a portion of the permanent magnets by:

(i) temporarily heating the portion of the permanent magnets to a temperature in the range of 0 - 100 °C above a Curie temperature thereof and below a Curie temperature for a remainder of the permanent magnets, thereby reducing a first threshold for switching of the north-south magnetic pole alignment of the portion of the permanent magnets; and

(ii) exposing the portion of the permanent magnets to a magnetic field which is directed oppositely to the north-south magnetic pole alignment of the permanent magnets, with the oppositely-directed magnetic field having a magnetic field strength which is above the first threshold for switching the alignment of the portion of the permanent magnets, while being below a second threshold for switching of the north-south magnetic pole alignment for the remainder of the permanent magnets.

36. The method of Claim 35 wherein the portion of the permanent magnets comprise neodymium-iron-boron (NdFeB) permanent magnets, and the remainder of the permanent magnets comprise samarium-cobalt (SmCo) permanent magnets.